HULL 1275A

and

HULL 1275B

MARINE SSB RADIOTELEPHONE

OPERATION AND MAINTENANCE MANUAL

HULL ELECTRONICS COMPANY

SECTION I

INTRODUCTION

GENERAL DESCRIPTION

This equipment is designed to provide long-range radiotelephone communications between ships and from ships to private or public shore stations, operating in the High Seas marine bands. Provision is made for 20 channels: Ten channels for ship-to-ship or ship to private business or operational shore stations. (Both stations will alternately transmit and receive on the same frequency. In this manual, we will refer to these channels as the ten SHIP channels.) Ten additional channels are provided for ship to public correspondence stations. (In this service, the ship always transmits on a lower frequency than the shore station. Throughout this manual we will refer to these channels as the TEL Channels.)

An additional feature of this equipment is that it is possible to listen to the ship transmitting frequency on the TEL Channels. Inter-ship communication is not permitted nor is it possible on these channels. This feature is included only as a monitoring aid.

Three transmitting modes are provided:

a. SSB with full carrier: Used for establishing initial contact on TEL Channels.

b. SSB with pilot carrier: Used for subsequent transmission on TEL Channels.

c. SSB with suppressed carrier: Used for all transmissions on ship channels.

Nominal power output is 200 watts PEP, but may be reduced to 150 watts PEP maximum where required, by means of an internal Hi-Lo power switch.

This equipment meets or exceeds all applicable FCC requirements. It is designed to provide the utmost ease of operation. When properly installed and adjusted, improper manipulation of the front panel controls cannot result in unauthorized modes of operation on any channel.

All components are conservatively rated to provide long trouble-free service under extreme shipboard conditions. All frequencies are controlled by specially processed crystals in precision ovens to maintain extremely close frequency tolerance over long periods of time. Mechanical design is such that high humidity, temperature extremes, vibration and shock will have a minimum effect upon operation and life of the equipment.

The equipment consists of two major units: The Radiotelephone and the Power Supply. The radiotelephone is designed for bulkhead or shelf-mounting. The outer aluminum cabinet may be removed by loosening four captive screws on the front panel, allowing ready access to routine maintenance adjustments and tubes. The power supply may be mounted up to 12 feet from the radiotelephone in any convenient location.

EQUIPMENT FURNISHED

a. Radiotelephone, complete with tubes.

b. Power supply of specified voltage with fuses.

c. Handset and hanger.

d. Power Supply interconnecting cable; 12 feet long.

e. Instruction book with circuit diagrams and decals for front panel frequency marking.

ACCESSORIES AVAILABLE

a. Quartz crystals for each operating channel

b. Crystal ovens

c. Top-loaded transmitting antennas.

d. Multiband transmitting antennas.

e. Remote speaker and additional handset with hanger

TABLE I
PRIMARY PUBLIC CORRESPONDENCE CHANNELS (TEL)

STATION CALL		TRANSMIT FREQUENCY	TRANSMIT CRYSTAL	RECEIVE FREQUENCY	RECEIVE CRYSTAL
KMI	4-1	4072.4	5937.6	4371.0	5639.0
	8-1	8204.4	1805.6	8738.4	1271.6
	12-1	12382.5	2372.5	13161.5	3151.5
	16-1	16512.5	6502.5	17307.5	7297.5
	22-1	22045.5	12035.5	22671.0	12661.0
WOM	4-1	4123.6	5886.4	4422.2	5587.8
	8-1	8262.0	1748.0	8796.0	1214.0
	12-1	12361.5	2351.5	13140.5	3130.5
	16-1	16491.5	6481.5	17286.5	7276.5
	22-1	22066.5	12056.5	22692.0	12682.0
WOO	4-1	4091.6	5918.4	4390.2	5619.8
	8-1	8223.6	1786.4	8757.6	1252.4
	12-1	12396.5	2386.5	13175.5	3165.5
	16-1	16526.5	6516.5	17321.5	7311.5
	22-1	22031.5	12021.5	22657.0	12647.0

TABLE II
SHIP-TO-SHIP AND SHIP-TO-LIMITED COAST CHANNELS

CHANNEL		SHIP FREQUENCY	SHIP CRYSTAL
Ship	4-1	4136.3	5873.7
	4-2	4139.5	5870.5
Ship	6-1	6210.4	3799.6
	6-2	6213.5	3796.5
Ship	8-1	8281.2	1728.8
	8-2	8284.4	1725.6
Ship	12-1	12421.0	2411.0
	12-2	12424.5	2414.5
	12-3	12428.0	2418.0
Ship	16-1	16565.0	6555.0
	16-2	16568.5	6558.5
	16-3	16572.0	6562.0
Ship	22-1	22094.5	12084.5
	22-2	22098.0	12088.0
	22-3	22101.5	12091.5
	22-4	22105.0	12095.0
	22-5	22108.5	12098.5
IF			10010.0

TUBE CHART

TUBE NO.	TUBE TYPE	CIRCUIT FUNCTION
V1	12BZ6	TEL Rcvr. Channel Oscillator Buffer Amplifier
V2	12BE6	TEL Receiver Mixer
V3	12BZ6	TEL Receiver RF Amplifier
V4	12BZ6	SHIP Receiver and Transmitter Channel Oscillator Buffer Amplifier
V5	12BE6	Transmitter Mixer
V6	12BE6	SHIP Receiver Mixer
V7	12BZ6	SHIP Receiver RF Amplifier
V8	6GK6	Transmitter Driver
V9,10,11	6883B	Transmitter Power Amplifier
V12	12BZ6	Receiver & Transmitter 1st IF Amplifier
V13	6BH6	Carrier Injection Amplifier
V14	12BA6	Receiver 2nd IF Amplifier
V15	12AX7	(A) Product Detector (B) Receiver Audio Amplifier
V16	12AT7	(A) Receiver Automatic Gain Control Amplifier
V17	6GK6	Receiver A. F. Output
V18	7360	Balanced Modulator
V19	6EA8	(A) IF Oscillator (B) IF Oscillator Cathode Follower
V20	12AX7	1st & 2nd Microphone Amplifier
V21	12AT7	(A) VOX Audio Amplifier (B) Transmit Relay Control
V22	OA2	Voltage Regulator
V101	6BH6	TEL A Transmitter Channel Oscillator
V102	6BH6	TEL B Transmitter Channel Oscillator
V103	6BH6	SHIP A Transmitter Channel Oscillator
V104	6BH6	SHIP B Transmitter Channel Oscillator
V105	6BH6	TEL A Receiver Channel Oscillator
V106	6BH6	TEL B Receiver Channel Oscillator

TUBE CHART

TUBE NO.	TUBE TYPE	CIRCUIT FUNCTION
V1	12BH7	TRF, IFT, Diesel Oscillator Buffer Amplifier
V2	12BE6	TRF, Detector Mixer
V3	12BA6	TRF, Detector RF Amplifier
V4	12BE6	AMD, Detector and Transmitter Channel Oscillator Buffer Amplifier
V5	12BA6	Transmitter Mixer
V6	12BA6	AMD, Detector Mixer
V7	12BE6	AMD, Detector RF Amplifier
V8	6DE6	Transmitter Driver
V9, 10, 11	6BQ6	Transmitter Power Amplifier
V12	12BZ6	Detector & Transmitter 1st IF Amplifier
V13	6DE6	Detector 2nd IF Amplifier
V14	12BA6	Receiver 1st IF Amplifier
V15	12AV7	(A) Product Detector
V16	12AV7	(B) Detector Audio Amplifier
V17	6DE6	(A) Detector Automatic Gain Control Amplifier
V18	6BA6	Receiver A.F.C. Output
V19	6BA6	Receiver Squelch
V20	6BA6	(A) IF Oscillator
V21	12AV7	(B) IF Oscillator Cathode Follower
V22	12AV7	(A) & 2nd Mixer-Osc. Amplifier
V23	6DE6	(A) VOX Audio Amplifier
V24	6BA6	(B) Transmit Beat Control
V25	6BA6	Voltage Regulator
V26	6BH6	TEL A Transmitter Channel Oscillator
V27	6BH6	TEL B Transmitter Channel Oscillator
V28	6BH6	SSTP A Transmitter Channel Oscillator
V29	6BH6	SSTP B Transmitter Channel Oscillator
V30	6BA6	TEL A Receiver Channel Oscillator
V31	6BA6	TEL B Receiver Channel Oscillator

SECTION III

OPERATION

CAUTION

DO NOT ATTEMPT TO TRANSMIT FOR AT LEAST 10 MINUTES AFTER THE VOLUME CONTROL POWER SWITCH IS TURNED ON. This period is required for the crystal ovens to stabilize the operating frequency. During the first few minutes after power is applied, the frequency changes so much that in addition to your signals being unintelligible, the output frequency will be in violation of FCC Regulations. Do not change BAND switch while transmitting.

GENERAL.

This radiotelephone will permit communications between a ship and three classes of stations: ship stations, limited coast stations, and public correspondence stations. The method of operating this equipment is simple and similar in all cases, but in order to provide detailed step-by step procedure with desirable explanations of the purpose of each step, this Section is sub-divided as follows:

Front Panel Controls - Detailed functioning of each control

VOX - Discussion of voice operated transmit switching

SHIP - Working Ship to Limited Coast Station

TEL - Working public correspondence stations.

No attempt should be made to energize this equipment until it has been properly installed, licensed, and tested by a licensed technician. Your station log book must contain an entry to this effect.

The operator of this equipment must hold a valid third class operator's license, although he may permit unlicensed persons to speak over the microphone under certain conditions. Refer to applicable FCC Rules and Regulations.

FRONT PANEL CONTROLS

This equipment is designed so that after proper installation and adjustment, it is not possible to transmit on an unauthorized mode or frequency. Of course, this does not mean that no matter how you operate the equipment you will achieve satisfactory results. To enable you to do that, you must understand something of the function of each control as well as prescribed operating procedures. The function of each control is described in detail below.

VOLUME-POWER OFF. This control incorporates an on-off switch to control power to the receiver and transmitter. When it is in the Off position, it will remove all power from both sections regardless of the position of the TRANSMITTER (TRANS) control. Rotating this control clockwise will simultaneously apply power to the receiver and transmitter circuits unless the TRANSMITTER control is in the OFF position. It also controls the audio level to the speaker(s) or handset(s).

SENSITIVITY. This control is used to increase or decrease the sensitivity of the receiver. Its effect will be similar to that of a Squelch control.

When the SENSITIVITY control is fully clockwise, the Automatic Gain Control circuits will automatically adjust all incoming signals to the same audio level. Even the strongest signals will not be much louder than the noise and static always present at the antenna.

With the SENSITIVITY control fully counterclockwise, the Automatic Gain Control Circuit is disabled and the loudness of received signals will be proportional to their strength at the antenna.

At some intermediate position of this control it will be found that weak signals and noise produce little audio from the speaker, but all signals above a certain level result in about the same higher level of audio volume.

LAMPS (LIGHTS). This control varies the brightness of illumination through the control panel and channel tables.

SPEAKER. This control selects the local or remote microphone and permits routing of receiver audio in various ways. Several options can be selected at the time of installation. If a remote speaker and a remote handset are used, the normal routing is as follows:

SPEAKER OFF: Received signals will be heard only on the local handset

SPEAKER ON: Signals will be heard on the built-in speaker and on the remote speaker.

REMOTE: Signals will be heard only on the remote handset.

RING: Signals will be heard only on the local handset. If an optional Selective ringer has been installed, a bell will ring if a station is calling you.

The local microphone and push-to-talk switch operate in the OFF and ON positions. The remote microphone and push-to-talk switch operate on the REMOTE position. Transmitter control is disabled in the RING position.

TRANSMITTER (TRANS). When in the OFF position, the transmitter power amplifier tube filaments and the high-voltage power supply are turned off. This switch should be placed in the OFF position if it is desirable to have the receiver on but it is not expected that the transmitter will be used within the next half-hour. After turning the transmitter ON, you should wait a full minute for the high power tubes to warm up.

The extra tube life and reliability obtained by placing this switch in the OFF position during long listening periods is well worth the inconvenience of waiting a minute after turning them ON.

When the transmitter switch is in the NORMAL position, transmitter standby power is applied and you can transmit by pushing the button on the handset.

When on VOX, switching from transmit to receive is automatic. Read the discussion under 'VOX!

STATION AND BAND SWITCHES These are two controls that must both be properly set to select the desired channel frequency. The transmit and receive frequency in use may be read from the front panel Frequency Tables.

MODE. This switch in conjunction with the STATION switch performs complex electrical switching but its operation is simple and almost self-explanatory.

IF THE STATION SWITCH IS ON SHIP A OR SHIP B: The Mode Switch may be left in the SSB position for all communications. The transmission will be single-sideband with a fully suppressed carrier. Operation will be the same if the MODE switch is in the AM position. If the MODE switch is on Receive Ships (REC SHIPS), you will be able to receive but will not be able to transmit.

IF THE STATION SWITCH IS ON TEL A OR TEL B: When the Mode Switch is on AM the transmitted signal will include a conventional carrier and enable reception of your signals on conventional AM receivers. The carrier will activate a light at the shore station to indicate to the operator that a station is calling. You should switch to SSB as soon as permitted to do so by the shore station technical operator because only in the SSB mode is the full benefit of single-sideband achieved.

B-Model radiotelephones are normally shipped with internal wiring arranged to provide for A3J emission on 6 mc TEL stations but can be changed to permit A3A and A3H operation. (See Schematic Diagram, Figure 5B.)

When the MODE switch is on REC SHIPS, you will not be able to transmit even when the PTT button is depressed. The receiver will operate on the ship calling frequency, not on the shore station frequency. There are frequent occasions when monitoring the ship frequencies will be beneficial.

VOX. The initials VOX stand for Voice Operated Xmit (transmit). When using VOX, the changeover from receive to transmit and vice versa is completely automatic. When no sound is reaching the microphone, the radiotelephone will be in a receive condition. When the operator speaks into the microphone, the receiver is instantly turned off and the transmitter is turned on. After almost any pause between words or sentences, the transmitter is automatically turned off and the receiver is again turned on.

When using single-sideband, VOX offers several advantages in addition to the obvious ease of operation. It enables the operators to carry on a normal "telephone type" conversation with a very rapid exchange of information. It enables each station to spend as much time as possible listening. It enables you to quickly detect if an interfering station is attempting to use the channel while you are in conversation.

The carrier power transmitted by a single-sideband suppressed carrier station such as this is less than one ten-thousandth as strong as the voice peaks transmitted. A 200-watt SSB station will transmit a carrier of less than .02 watts. It is therefore obvious that even if you hold down the push-to-talk button, no one but you will know it unless you are talking. It follows that if you are not talking, you might as well be listening.

If you are an experienced AM operator, you will face a short period of mental readjustment when first using VOX. The automatic changeover from receive to transmit and back again will disturb you. After you begin to speak, if you are in a quiet location, you will hear the small relays change over to transmit. You will feel that your first word was completely lost.

Actually, the changeover is so fast that only a very slight part of the first syllable is clipped. It is very seldom that this will result in any loss of intelligibility. A check with other stations will verify this. The reason that it seems longer is that you detect the delay between the instant you begin to speak and the instant the sound of the relay closing reaches your ear. Because sound travels slowly in air, the transmitter will have been on a relatively long time before the sound of the relay reaches you.

If you pause in speaking, after a slight delay, the transmitter will go off and the receiver will come on. This will not seem unnatural if you were ending your transmission but it will disturb you if you were simply pausing between sentences. Train yourself to ignore it; just continue talking.

SHIP OPERATION

This section details step by step operating procedure for communication with ship stations or limited coast stations. (Limited coast stations include "Company Stations" and other non-telephone stations.) It is assumed that the equipment has been properly licensed, installed, adjusted, and tested. The information below will aid a qualified operator in familiarizing himself with this readiotelephone.

PRELIMINARY CONTROL SETTINGS

1. Speaker to ON
2. Sensitivity fully counter-clockwise
3. Transmitter (TRANS) to Normal
4. MODE to SSB
5. BAND to desired band
7. STATION to desired station. The operating frequency obtained with any position of the BAND and STATION switches is indicated on the front panel frequency table.

WARMUP

1. VOLUME clockwise to mid-position. The power switch will operate applying receiver and transmitter power. WAIT AT LEAST 10 MINUTES for crystal oven stabilization before attempting to transmit.

2. SENSITIVITY control clockwise until background noise or conversation is heard. The front panel meter indicates relative signal strength on receive. It will deflect to the right as the sensitivity control is rotated counter-clockwise or as received signal strength increases.

OPERATE: NORMAL (Push-to-Talk)

1. Depress the handset push-to-talk button. The red TRANSMIT lamp will light. The front panel meter will indicate PA cathode current. With no modulation, this current should be .08 amperes.

2. Speak into the microphone in a normal tone of voice-- DO NOT SHOUT -- The meter will deflect to about .25 amperes during normal conversation but will "bounce" much more than on an AM transmitter. This is normal. When you are not talking, the transmitter is "idling" and almost no power is being transmitted even though you have depressed the PTT button. As you speak, the power varies in accordance with the level of your voice. The transmitter incorporates an Automatic Audio Level Control which automatically adjusts for normal variations in voice level. Shouting is not only unnecessary but results in very distorted and often unintelligible signals.

   If the panel meter remains nearly steady at about .25 amperes your voice is too loud.

   In very noisy installations, everyone tends to raise his voice but this will not improve communications. There is also a tendency to raise one's voice if the received signal is weak or partially masked by noise or static. Make yourself conscious of these tendencies and train yourself to always speak in a normal tone of voice. You will be rewarded with many compliments on the sound of your signal.

   DO NOT SHOUT INTO THE MICROPHONE!

3. When you have finished speaking, release the push-to-talk button to restore the equipment to the receive condition. The red TRANSMIT lamp will go out.

4. NOTE: This equipment does not employ any large relays; transmit-receive switching is quiet and extremely fast. It is very good operating technique to release the PTT button during pauses in your speech. This enables you to receive the other station if he wants to "break" your conversation. If the other station is using VOX operation, he will likely do this often.

   You should also be aware that in single-sideband operation, you cannot "push the button" on another station. Even though the PTT button is operated, the only time you put out any signal is while you are talking. Holding the button down when you are not actually speaking serves only to disable your speaker.

OPERATE: VOX

1. Place the TRANSMITTER switch on VOX.

2. Speak into the microphone in a normal tone of voice. The red TRANSMIT lamp will light and the panel meter will deflect in accordance with your voice. The meter should "bounce" between about .10 and .25 amps. If it remains nearly stationary at .25 amps, you are speaking too loudly, or too close to the microphone.

3. When you pause, the red TRANSMIT lamp will go out indicating that the equipment has returned to the receive condition. Read the preceding discussion of VOX.

TEL OPERATION

The step-by-step operating procedure for use when communicating with public correspondence shore stations (TEL stations) is very similar to the procedure for SHIP operation. The important difference is

that most telephone stations monitor your frequency with AM Receivers. It may therefore be necessary to establish initial contact on AM. This is accomplished with the MODE switch in the AM position. After contact has been established, you may switch to SSB.

PRELIMINARY CONTROL SETTINGS

1. Speaker to ON.
2. SENSITIVITY fully counter-clockwise.
3. TRANSMITTER (TRANS) to NORMAL.
4. MODE to AM.
5. BAND to desired band.
6. STATION to desired station.

WARMUP

1. VOLUME clockwise to mid-position. The power switch will operate applying receiver and transmitter power. WAIT AT LEAST 10 MINUTES for crystal oven stabilization before attempting to transmit.
2. SENSITIVITY clockwise until background noise or conversation is heard.

OPERATE

1. Depress the handset push-to-talk button. The red TRANSMIT lamp will light. The panel meter will indicate approximately .2 amperes PA Cathode current with no modulation.
2. Call the shore station and announce your ship's name, call letters, and location. Speak into the microphone in a normal tone of voice. DO NOT SHOUT. Repeat the call three times. Wait at least one minute for the shore station technical operator to reply.
3. When the technical operator answers, advise him that you are "going to single-sideband, this frequency".
4. MODE switch to SSB. The PA Cathode current will drop to about .09 amps with no modulation. The meter will deflect upward to approximately .2 amps on voice peaks. Announce your ship's name and call letters. After contact has been established on single sideband, place your call in the normal manner.

SECTION IV

INSTALLATION

RADIOTELEPHONE:

Select a convenient operating location for the radiotelephone. As nearly as possible, the position selected should be in a vertical line between the antenna and the radio ground. It is important that the radiotelephone be provided with adequate ventilation.

In custom-built installations when the equipment must be built into a closed compartment of limited volume it is recommended that a cooling fan or blower be installed in such a manner as to force air into the holes in the bottom of the support bracket. This fan can be connected to the power supply terminal strip to be automatically turned on and off by the radiotelephone power switch.

The outer cabinet can be removed by loosening the four captive screws on the front panel. The speaker and lamps behind the frequency tables are connected to the chassis. Care should be exercised in removing or replacing the outer case.

The chassis may be pivoted forward or removed from the support bracket by removing the two screws on the sides of the chassis near the top.

It is not necessary to remove the control panel for any adjustments normally required during installation. If, however, it is desirable to remove this panel for any reason, first remove the BAND knob by loosening the two hex-head socket screws with the wrench secured to the chassis near the top center. The panel may then be freed by removing the four screws near the corner. The plastic panel is permanently secured to the aluminum backup panel and they should be removed together as a unit.

The two antenna cables, the power supply cable and the handset cable should be routed through holes in the bottom or lower rear of the support bracket. The cables should be routed and secured so as not to rest against any chassis components at any time. Use care to prevent the power cable wires from being pinched between the chassis and the support bracket.

POWER SUPPLY

The power supply may be mounted in any convenient location within cable length (12 feet) of the radiotelephone. See Figure 2.

Adequate clearance to permit removal of the cover should be allowed. The fuse holders should be readily accessible. It is recommended that an adequate supply of spare fuses of the correct value be mounted on or near the power supply.

The power supply will operate in any position but because it is quite heavy care must be exercised that pounding in heavy seas will not place undue strain on the mounting screws. For this reason it is best to keep the mounting plate horizontal.

The wires or cable connecting to the a.c. source should have enough slack to permit access to the bottom of the power supply for maintenance. These wires should be B&S #10 or larger. A double pole disconnect switch or fuse block should be installed to permit opening both sides of the a.c. supply lines when it is necessary to remove any wires from the power supply or radiotelephone terminal strips.

The power supply chassis should be grounded.

The common or grounded side of the a.c. supply line should be connected to the power supply "AC IN" terminal nearest the "GROUND" terminal.

The primary power wires should connect to the a.c. generator distribution panel. No other equipment should receive power through these wires. While the current drawn is less than 10 amps on voice peaks, it varies widely during modulation. Good regulation is essential for proper equipment operation.

ANTENNAS:

The antenna matching network built into this radiotelephone will accommodate a variety of antennas without the necessity of expensive external antenna tuners.

Multiband "Trap" antennas are relatively new. They have been proven the best choice for most ship and shore installations in the marine service in the 4 through 23 megacycle bands. Unlike the ordinary center-loaded low frequency antennas, trap antennas are pre-tuned to operate on 2 or more frequencies without additional base loading. They can be fed with ordinary 52 ohm coaxial cable.

GROUND SYSTEM

IMPORTANT! A radio ground system which is quite satisfactory for 2 to 3 mc operation may be of little value at frequencies above 4 mc.

Vertical marine antennas radiate energy because of RF current flow between the antenna and ground. The ground must be at or near the base of the antenna and must be physically large compared to the antenna. These dimensions must be considered relative to the wavelength of the radio frequency being transmitted. The following table shows the approximate relationship between frequency and wavelength.

FREQUENCY	WAVELENGTH
2 mc	234 feet
4 mc	117 feet
6 mc	78 feet
8 mc	58 feet
12 mc	39 feet
16 mc	29 feet
22 mc	21 feet

In a 2 mc system, the surface of the sea is the ground reference. A 2 mc radiotelephone 23 feet above the surface is only .1 wavelength above ground and may be loaded satisfactorily. By comparison, at 22 mc, .1 wavelength is only 2 feet.

The sea cannot be considered as the ground reference above 4 mc. At these frequencies, the only practical solution is to construct or make use of existing structure that is within a foot or so of the bottom of the antenna.

One solution found successful is to lay a copper screen on top of the "house" and paint it for protection against the weather. The antenna is then mounted 6 inches to a foot above this screen near the center. The antenna is fed from the center conductor of a coaxial cable. The outer conductor of this cable is connected to the screen below the base of the antenna.

Another solution which has been found effective on commercial vessels having extensive rigging and on sailboats is to mount the antenna on top of the mast. All stays and the mast, if it is metal, are electrically bonded to the outer braid of the coax.

A third method which can be satisfactory is to run copper straps or heavy wire radially from the outer coax braid at the base of the antenna to all armored cables, rails, stacks, etc. near the antenna. When this approach is used, it is important to keep in mind that it will be effective only to the extent that it approximates a large metal plate below the antenna. One or two radials will not be sufficient. At least 6 should be used.

The ground system may be improved by bonding to the ground strap all metal objects in the immediate vicinity of the installation, such as rails, stacks, permanent halyards, plumbing, conduit, engine etc. In general, additional bonding that increases antenna current (or transmitter loading) may be considered an improvement. All connections should be made with heavy connectors, and should be soldered if possible. If lugs are required, the lugs and metal connections should be scraped clean and bright, and the attaching nuts and bolts tightened as much as possible.

Care taken in the installation of grounds results in a secondary benefit, in that it almost invariably creates quieter receiving conditions--less noise when the vessel is under way. The importance of a good ground system cannot be over-emphasized. If overlooked, performance will be far below par.

SECTION V

TUNEUP PROCEDURES

CAUTION

Voltages dangerous to life are present in this equipment. High voltages are present in the transmitter circuits even in the receive condition.

Very large filter capacitors are used in this equipment. Bleeder resistors will normally discharge these capacitors within 2 minutes after power is removed but all terminals and bare wires should be grounded to the chassis before being touched.

High RF voltages appear in this equipment. When the VOX circuit is functioning, a loud noise or a slight bump of the handset can cause the unit to switch instantaneously to transmit.

WARNING

DO NOT ATTEMPT TO TRANSMIT FOR AT LEAST 10 MINUTES AFTER THE VOLUME CONTROL POWER SWITCH IS TURNED ON. This period is required for the crystal ovens to stabilize the operating frequency. During the first few minutes after power is applied, the frequency changes so much that in addition to your signals being unintelligible, the output frequency will be in violation of FCC Rules.

GENERAL

All controls and adjustments necessary for normal tuneup are readily accessible from the front of the chassis with the control panel in place and the outer case removed. The radiotelephone should remain fastened in its support bracket during these adjustments.

The outer case may be removed by loosening the four captive bolts on the front panel.

All exciter and receiver tanks are factory-aligned bandpass circuits. They should not require adjustment except at very long intervals. They cannot be properly adjusted simply by tuning for maximum output. Read detailed alignment procedure.

Do not attempt to adjust oscillator frequencies without a digital frequency counter. Read detailed alignment procedure.

Do not disturb the settings of the Harmonic Traps without first reading the detailed alignment procedure.

Before beginning tuneup, check that the equipment is properly grounded.

Before keying the transmitter, check that the antenna jack corresponding to the band in use is connected to a dummy load or to the proper antenna. Attempts to operate the final Power Amplifier without a proper load can result in permanent damage to transmitter components.

When tuning into an antenna, the transmitter frequency should be carefully monitored to assure that no interference is being caused to other stations desiring to communicate on the same frequency. Note that on TEL channel, the ship transmitting frequency can be monitored when the MODE switch is in the REC SHIPS position. On other positions of the MODE switch, the shore station frequency will be received.

During tuneup, the transmitter should be keyed only for short intervals (approximately 1 minute, maximum) and allowed to rest in the receive condition for an equal period of time to minimize heating of components which can occur when not properly tuned and loaded.

Routine tuneup has been greatly simplified by the use of bandpass circuits in the exciter stages. When the proper antennas are used, it will be found that tuning the PA and antenna circuits to one frequency near the center of each 100 kc band will result in satisfactory operation at all frequencies within that band.

Tuning and loading of the transmitter to the antenna can be accomplished without any special instruments or tools but more precise results can be achieved if a good RF VTVM is used to monitor the voltage at the antenna jack. This is particularly advantageous in setting the -40, -16, and -6db carrier level controls.

TUNEUP CONTROLS - Location and Function

The front panel METER indicates total PA cathode current on transmit (.5 Amp full scale).

The TUNE-OPERATE switch near the lower center of the main chassis, in conjunction with the MODE switch on the front panel, provides transmitter keying and carrier injection for tuning and loading. In the LO PWR positions, it reduces screen voltage to the PA. The function of each switch position is outlined below.

HI PWR OPERATE: This is the normal position. The transmitter can be keyed by the push-to-talk (PTT) switch on the handset or by the voice in VOX operation.

LO PWR OPERATE: Same as HI PWR OPERATE, except that PA screen voltage is reduced to limit PA output power to less than 150 watts PEP.

TX LOCK: Used to adjust PA resting current and carrier level. Conditions are the same as in the HI PWR OPERATE position except that the transmitter is keyed so that the PTT switch need not be held down.

1. When the STATION switch is on SHIP A or SHIP B, the carrier level can be set -40db or more below PEP.

2. When the STATION switch is on TEL A or TEL B and the MODE switch is on SSB, the -16db carrier level can be set.

3. When the STATION switch is on TEL A or TEL B and the MODE switch is on AM, the -6db carrier level can be set.

LOW PWR TUNE: Used for initial tuneup. Transmitter is keyed. PA screen voltage is reduced. Carrier is injected regardless of the position of the STATION switch.

1. When the MODE switch is on SSB, the carrier will be less than 150 watts PEP.

2. When the MODE switch is in AM, carrier level sufficient to provide full low power PEP is inserted.

HI PWR TUNE: Used for last tuneup steps. Transmitter is keyed. Full PA screen voltage is applied. Carrier is injected regardless of the position of the STATION switch.

1. When the MODE switch is in SSB, the carrier will drive the PA to less than rated PEP.

2. When the MODE switch is in AM, the carrier will drive the PA to rated PEP.

3. The PA is subjected to continuous maximum drive and power input in this mode. Average power input is equal to normal peak power input. Maximum control grid, screen grid, and plate dissipation will occur. Maximum RF voltage and current will appear in the PA output circuits. Operation in this mode for extended periods should be avoided.

4. If the PA is operated off-resonance in this mode, the HV power supply fuse will blow. This is normal and desirable protection for the PA tubes. Initial tuning and loading should be accomplished on LO PWR TUNE.

The final Class AB power amplifier stage is tuned and loaded much like the familiar Class C amplifier with a pi tank circuit and a series loading coil.

The TUNE capacitors resonate the tank for minimum PA cathode current.

The LOAD capacitors adjust the load impedance reflected to the PA tubes to produce the specified value of PA current.

The ANTENNA COIL resonates the antenna circuit and matches the transmission line to the pi network. It is adjusted for maximum PA current at resonance.

TUNEUP STEPS

Read the above General Information and Cautions before performing any of the following steps:

WARMUP

1. TUNE switch to HI PWR OPERATE.

2. VOLUME control clockwise to apply receiver, exciter and crystal oven power. Wait at least 10 minutes for oven stabilization before keying the transmitter.

3. TRANSMITTER (TRANS) switch to NORMAL to apply PA plate and filament voltage. Wait at least one minute before keying the transmitter.

SET PA RESTING CURRENT

1. STATION switch to any SHIP channel

2. MODE switch to SSB.

3. MIC gain fully counter-clockwise

4. TUNE switch to TX LOCK to key transmitter.

5. PA BIAS control for .08 Amp PA cathode current on the front panel meter (500 ma or .5 Amp full scale).

6. TUNE switch to LO PWR OPERATE.

PA TUNE - INITIAL STEPS

1. BAND switch to desired band.

2. STATION switch to the transmitting frequency nearest to the center of the band. (See page 3.)

3. MODE switch to SSB.

4. Preset PA TUNE capacitor to mid range (slot vertical).

5. Preset PA LOAD capacitor 1/4 turn from full clockwise (maximum capacity).

6. The next three steps should be performed in rapid sequence to minimize on-air time and reduce PA tube and tank circuit heating.

7. TUNE switch to LO PWR TUNE to key the transmitter and apply reduced carrier.

8. PA TUNE capacitor to minimum PA cathode current.

9. TUNE switch to LO PWR OPERATE to unkey the transmitter.

10. If the minimum PA cathode current in Step 8 was greater than .2 Amp, rotate the LOADING capacitor 1/8 turn clockwise to reduce loading, then repeat Steps 7, 8, and 9.

ANTENNA COIL ADJUSTMENT

Locate the antenna coil tap position which results in greatest PA loading as follows:

1. Move the antenna coil tap for the band in use one turn at a time and repeat Steps 7, 8, 9, and 10 above. If a dip of at least 10% in PA cathode current cannot be obtained, rotate the LOADING capacitor slightly clockwise and repeat.

2. Return the antenna coil tap to the position which results in highest PA cathode current dip.

3. Repeat all PA TUNE - INITIAL STEPS and ANTENNA COIL ADJUSTMENT steps on each band.

CAUTION

Do not proceed to LOW POWER tuneup until INITIAL STEPS and ANTENNA COIL ADJUSTMENT have been completed. Do not proceed to HIGH POWER tuneup until satisfactory completion of LOW POWER tune on all bands. Doing so will likely result in damage to transmitter components. If satisfactory LOW POWER tuneup can not be accomplished, carefully recheck all antenna, ground and transmission line connections for opens or shorts. Be sure that the ANTENNA and GROUND requirements outlined in Section IV are being observed.

PA TUNE - LOW POWER

1. MODE switch to AM.

2. STATION switch to any SHIP channel.

3. TUNE switch to LOW PWR TUNE to key the transmitter and inject maximum carrier.

4. PA TUNE capacitor to minimum PA cathode current. Note the front panel meter reading.

5. TUNE switch to LO PWR OPERATE to unkey the transmitter.

6. If the current in Step 3 was not .225 Amp, rotate the LOAD capacitor slightly clockwise to decrease the current or counterclockwise to increase the current.

7. Repeat steps 3, 4, 5 and 6 until the proper PA cathode current is obtained on each band.

NOTE

Visually determine that the PA TUNE capacitor slots are not horizontal, indicating that the capacity range has been exceeded and the tank is not in resonance. If the PA TUNE capacitor is at maximum capacity, either the PA LOAD capacitor is too far counterclockwise, the ANTENNA COIL tap is improperly set, or the antenna and ground system is inadequate.

CAUTION

DO NOT TUNE THE TRANSMITTER UNDER HIGH POWER CONDITIONS UNTIL ALL THE PRECEDING STEPS HAVE BEEN PROPERLY COMPLETED.

FINAL TUNEUP - HIGH POWER

Tune and load the PA for a cathode current of .325 Amp as follows:

1. MODE switch to AM.

2. TUNE switch to HI PWR TUNE to key the transmitter, applying full drive and full screen voltage.

3. PA TUNE capacitor to cathode current dip. Note the meter reading.

4. TUNE switch fully counterclockwise to HI PWR OPERATE.

5. If the current in Step 2 above was not 325 ma., adjust the LOAD capacitor as under LOW POWER TUNEUP.

6. Repeat on each band.

7. Double check the position of the TUNE switch. It should be in the HI PWR OPERATE position except in areas where power output must be limited to less than 150 watts PEP, in which case it should be left on LO PWR OPERATE.

8. If the carrier level is not going to be checked next, proceed to MICROPHONE GAIN ADJUSTMENT at the end of this section.

CARRIER LEVEL ADJUSTMENT WITH VTVM OR OSCILLOSCOPE

The three carrier level controls (-40db, -16db, and -6db,) should not require frequent adjustment but the accuracy of their settings should be checked during tuneup and after any tube replacement or maintenance.

The preferred method is by measurement of the voltage at the antenna connector with the RF probe of a good VTVM such as the Hewlett-Packard 410B or 410C. If such an instrument is not available, a wide band oscilloscope can be substituted. The section on carrier level adjust, following, describes a satisfactory but less desirable method using only a receiver and the radiotelephone front panel meter.

Carrier Level, -40db Adjustment

1. STATION switch to any SHIP channel.
2. MODE switch to SSB.
3. TUNE Switch to TUNE.
4. Measure the antenna voltage (With a 50 ohm resistive antenna, it will be approximately 100 volts.)
5. TUNE switch to TX LOCK
6. Measure the antenna voltage. It must be less than .01 times the HI PWR TUNE voltage (-40db).
7. If the carrier level is too high, carefully adjust the -40db control for minimum voltage with the TUNE switch in TX LOCK.
8. Return the TUNE switch to HI PWR OPERATE. The carrier level control need be set on only one band.

Carrier Level, -6db Adjustment

1. STATION switch to any TEL channel except 6 MC
2. MODE switch to AM
3. TUNE switch to HI PWR TUNE
4. Measure the antenna voltage (approximately 100 volts).
5. TUNE switch to TX LOCK.
6. Measure the antenna voltage. It must be .5 to .7 times the reading obtained in Step 4.
7. If the voltage in Step 6 is incorrect, adjust the -6db control for the correct reading.
8. TUNE switch to HI PWR OPERATE
9. Repeat all the above steps on each band. Set the -6db carrier level control so that the voltage on all bands is within the prescribed limits. Note that 6 mc TEL channels may be set up for -40db carrier. (See Schematic Diagram, Figure 5B).

Carrier Level, -16db Adjustment

1. STATION switch to any TEL channel except 6 mc.
2. MODE switch to AM.
3. TUNE switch to HI PWR TUNE.
4. Measure the antenna voltage.
5. TUNE switch to TX LOCK.
6. MODE switch to SSB.
7. Measure the antenna voltage. It should be .16 times the voltage in Step 4 (-16db) but is acceptable if between .13 and .19 times this voltage.
8. If the voltage in Step 7 is incorrect, adjust the -16db carrier control.
9. TUNE switch to HI PWR OPERATE
10. Repeat all the above steps for each band. Set the -16db control at the compromise setting which places all bands within limits.

CARRIER LEVEL ADJUSTMENT WITHOUT VTVM OR OSCILLOSCOPE

The following procedure will give satisfactory results if carefully performed but the results will not be as accurate as in the preceding paragraph.

Carrier Level -40db Adjustment

1. STATION switch to any SHIP channel.
2. MODE switch to SSB.
3. TUNE switch to TX LOCK
4. Tune a nearby receiver having an "S" meter to the transmitter frequency.
5. Verify the correct receiver setting by alternately rotating the TUNE switch from TX LOCK to HI PWR OPERATE.
6. TUNE switch to TX LOCK.
7. Carefully adjust the -40db control for minimum receiver S Meter reading.
8. TUNE switch to HI PWR OPERATE.

9. Disconnect the auxiliary receiver antenna or detune the receiver from the transmitter frequency to protect the receiver input circuits during subsequent full-power transmitter tests.

Carrier Level - 6db Adjustment

1. STATION switch to any SHIP channel
2. MODE switch to AM.
3. TUNE switch to TX LOCK
4. Adjust PA BIAS for exactly 80 ma (.08 ma (.08 Amp.)
5. STATION switch to any TEL channel.
6. Adjust -6db Carrier Level Control for PA cathode current of 210 ma.
7. TUNE switch to HI PWR OPERATE.
8. Check the carrier level on each band. If necessary, arrive at a compromise setting of the -6db control to keep the current in Step 6 between 210 and 240 ma.

Carrier Level -16db Adjustment

1. STATION switch to any SHIP channel.
2. MODE switch to SSB
3. TUNE switch to TX LOCK
4. Adjust PA BIAS for exactly 80 ma.
5. STATION switch to any TEL channel.
6. Adjust -16db control for PA cathode current of 90 ma.
7. TUNE switch to HI PWR OPERATE
8. Check the carrier level on each band. If necessary, arrive at a compromise setting of the -16db control to keep the current in Step 6 between 85 and 95 ma.

MICROPHONE GAIN ADJUSTMENT

1. STATION switch to any SHIP channel.
2. Press the push-to-talk button on the handset and while talking in a normal tone of voice, adjust the MIC GAIN control until the average PA cathode current is 150 ma. The meter should bounce between 100 and 200 ma with normal speech input. Whistling, prolonged "ah's" or counting slowly cannot be used for modulation during the adjustment.

SECTION VI

THEORY OF OPERATION

GENERAL.

It is not within the scope of this manual to present a treatise on single sideband techniques. This section will, however, explain in some detail the more unusual circuits utilized in this radiotelephone.

SIGNAL FLOW (refer to block diagram or schematic)

RECEIVE ON SHIP'S TRANSMITTING FREQUENCY

Channel Oscillator (V101, V102, V103, or V104) output is amplified by V4, the plate of which is tuned to the desired oscillator frequency and applied to the injection grid of the ship Receiver Mixer (V6).

Incoming signals at the antenna pass through the contacts of K3 (energized in this mode) and the resonant P.A. Plate tank circuit. Signals are then coupled through C908 and contacts on K2 (de-energized) to the grid of the RF Amplifier (V7) where they are amplified and coupled through a bandpass transformer to the signal grid of the mixer.

The signals out of the Mixer at the IF frequency are fed through an IF transformer to the crystal filter (Z1201) which passes only the upper sideband to the grid of the 1st IF Amplifier (V12). The IF signals are further amplified by V14 and fed to the grid of the Product Detector (V15A).

The output of the IF Oscillator (V19A) is coupled through Cathode Follower (V19B) to the cathode of V15A. The audio difference frequency out of the Product Detector is amplified by V15B and V17, then coupled to the speaker or handset.

RECEIVE ON TEL FREQUENCIES:

The signal flow is similar to the above, except that K3 is de-energized, V105 or V106 are the Channel Oscillators in use. The Receive Mixer is V2. The RF Amplifier is V3.

TRANSMIT ON SHIP FREQUENCIES:

Channel Oscillator (V101, V102, V103, or V104) output is amplified by V4, the plate of which is tuned to the desired oscillator frequency and applied to the injection grid of the Transmitter Mixer (V5).

IF Oscillator (V19A) output is applied to the signal grid of the Balanced Modulator (V18). Microphone voltage is amplified by V20A and V20B, then coupled to one deflection plate in V18. Almost no signal at the IF Oscillator frequency is present in the output of V18 due to the balanced circuitry but when audio modulates the deflection plate voltage, sidebands at the sum and difference frequencies are produced and coupled through T1801 to the Crystal Filter (Z1201). Only upper sideband frequencies are passed through the filter to the 1st IF Amplifier (V12) where they are amplified and fed to the signal grid of the Transmit Mixer (V5). The IF signals and Channel Oscillator output are mixed and the desired sum or difference frequencies are coupled through a bandpass transformer to the grid of the Driver (V8) where they are amplified and fed through a second bandpass transformer to the grids of the Power Amplifiers, (V9, V10, and V11). The output of the PA is matched to the proper antenna by the Pi-L network.

Series resonant traps shunt the harmonic output to ground. The Q of these traps is adequate to provide the additional harmonic attenuation required at all frequencies within the transmitting bands. At the fundamental frequency, these traps appear capacitive and form part of the tank circuit.

TRANSMIT ON TEL FREQUENCIES:

Signal flow is identical to that on SHIP frequencies except that the carrier is reinserted at the proper level.

The IF Oscillator signal is coupled to the grid of the Carrier Injection Amplifier (V13). The d-c grid voltage on this tube is controlled in the AM Mode by R1307 and in the SSB Mode by R1308. The cathode voltage is maintained positive with respect to ground by tube current and the current through R1306.

The cathodes of the Power Amplifiers (V9, V10, and V11) are connected through an RF filter to the cathode of diode D1301. The anode of this diode is connected to the Cathode of V13, which is heavily by-passed by C1307. If carrier injection is lower than desired, PA cathode voltage will be negative with respect to the voltage across C1302. D1301 will conduct, discharging this capacitor, and lowering the cathode voltage of V13. The gain of this state will increase until the additional drive to the PA and resultant increase in cathode voltage cause D1301 to decrease conduction.

When modulation is present, PA cathode voltage will go positive with respect to the voltage across C1307 causing D1301 to be reverse biased. Because of the long time constant for the discharge of C1307, the carrier level will be maintained nearly constant at the desired level.

DESCRIPTION OF THE OSCILLATOR CIRCUIT

This equipment employs seven crystal controlled oscillators of the electron-coupled Pierce type. Each employs a pentode tube having a non-resonant plate load. The screen of the tube serves as the plate of the oscillator circuit. The plate and screen source voltage is regulated by means of a type OA2 tube to approximately 150 volts. Oscillator qutput is at the fundamental frequency of the quartz plate.

The crystals employed are of the CR-27/U type. The crystals are operated into a nominal load capacity of 32 pf. This capacity is adjustable within narrow limits by means of an air dielectric variable capacitor. Temperature compensating capacitors are used for critical fixed capacitors.

All crystals are operated in cavity type ovens designed to maintain crystal temperature at 75° C with variations in ambient temperature from -55°C to 70°C.

CARRIER SUPPRESSION

The total amount of carrier suppression is the sum of that obtained in the balanced modulator and the attenuation of the crystal filter. Total carrier suppression always exceeds 40 db at the filter output.

The IF oscillator output is coupled to the control grid of a type 7360 beam-deflection tube balanced modulator (V18). The two plates of this tube are connected to opposite ends of the balanced primary winding of the first IF transformer. D-C bias on the tube deflection plates is adjusted so that the output plate voltages are of nearly identical amplitude and produce almost no output at the carrier frequency. The filter further attenuates the carrier frequency.

CARRIER REINSERTION AND AUTOMATIC CARRIER LEVEL CONTROL

In all modes of transmission, the carrier level at the grid of the first IF amplifier is more than 40 db below the upper sideband signal level. When a carrier is required, the IF frequency output of a sharp cut-off pentode, (6BH6) is coupled to the plate of the first IF amplifier where it combines with the upper sideband signals. The ratio of carrier to signal is automatically controlled at one of two predetermined levels, (-6db or -16db.)

The output of the IF oscillator is coupled to the control grid of the 6BH6 Carrier Injection Amplifier. The d-c grid voltage of this stage is set to produce the gain required for the proper carrier level.

The cathode of this stage, which is heavily bypassed for audio frequencies, is coupled through a silicon diode to the cathodes of the Power Amplifiers. If the PA cathode voltage is below a predetermined value due to insufficient carrier level, the injection amplifier cathode voltage will decrease, its gain will increase, and carrier level will increase until sufficient PA cathode voltage is developed.

PEAK POWER OUTPUT LIMITING

This equipment incorporates a circuit which automatically limits the peak envelope power to the authorized transmitter power.

The Automatic Audio Level Control circuit receives its input from the RF envelope peaks in the final amplifier grid circuit, and uses its output to control the gain of the exciting signal path. Because peak plate output occurs under conditions of peak drive, limiting the amount of grid drive also limits the peak output.

Stage gain and signal levels are such that PA grid current will flow before limiting occurs in any transmitter exciter stage. When PA grid current flows through a R902 in series with the bias supply, a voltage proportional the magnitude of the grid current is developed across this resistor. Under voice modulation conditions this voltage will vary at the syllabic rate. This voltage variation is coupled by a capacitor to a voltage doubler having a capacitor (C906) across its output terminals. The doubler will rapidly charge this capacitor, but discharge of the capacitor is slowed by the high resistance across it.

This voltage, which is negative with respect to ground, is applied to the control grid of the first IF amplifier tube (V12). This semi-remote cut-off pentode is part of the transmitter exciter signal path.

The effect, then, is that under low signal level conditions, the exciter operates at maximum gain, but when a peak signal level sufficient to cause the PA to draw grid current occurs, the exciter gain is almost instantaneously reduced to limit the level of the exciting signal.

SINGLE SIDEBAND GENERATION

Output of the radiotelephone is upper sideband on all channels. The output of the Balanced Modulator (V18) contains both sidebands but only the upper sideband at the IF frequency is passed by the crystal filter Z1201. This signal is amplified by V12 and coupled to the signal grid of the Transmit Mixer (V5), where it is combined with the output of the Oscillator Amplifier (V4).

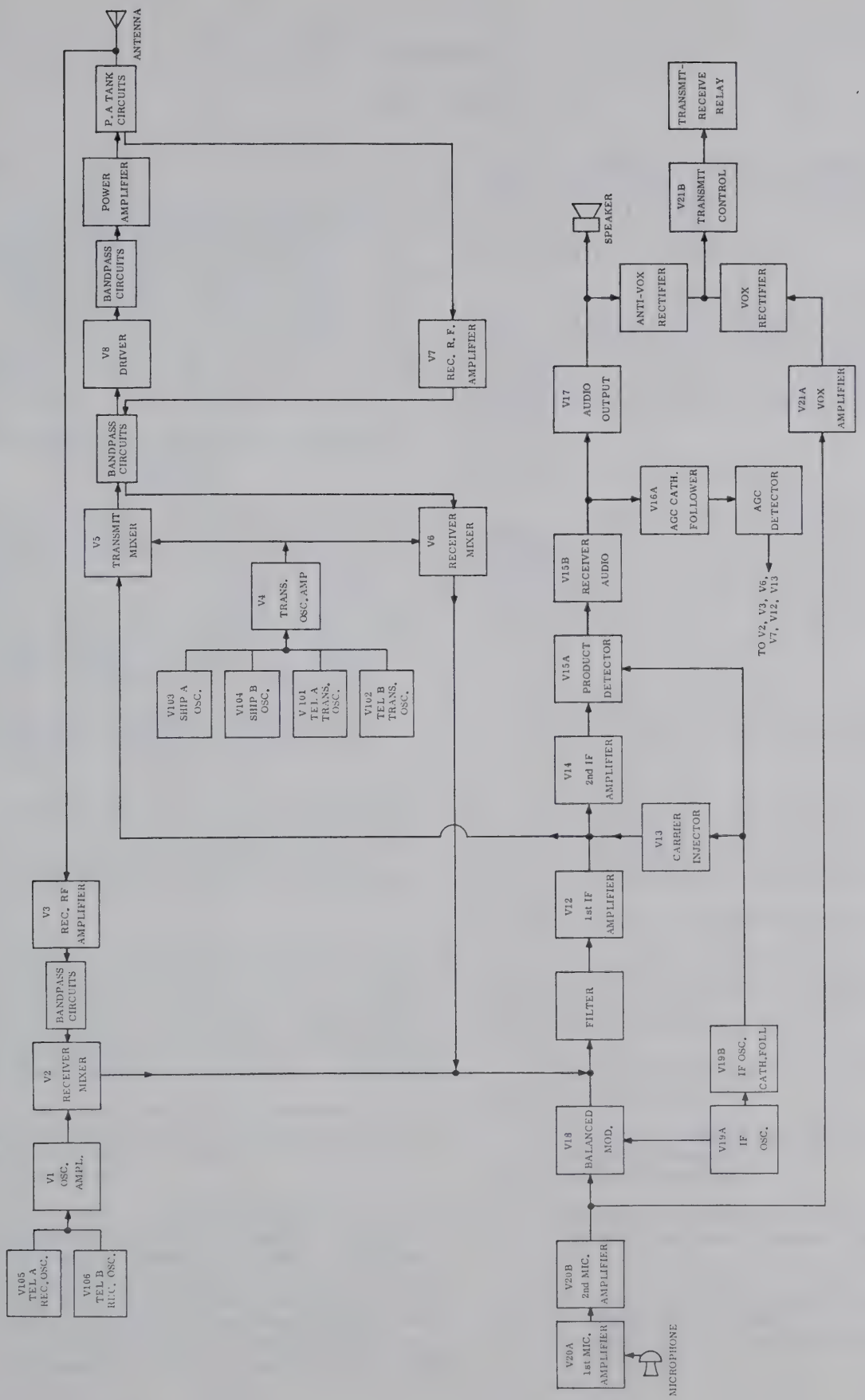


Figure 3. Block Diagram

SECTION VII

MAINTENANCE

GENERAL

No adjustments other than those in Section V of this manual should be attempted without proper test equipment and procedures. The circuits in this equipment have been designed to afford maximum stability. Except for periodic oscillator frequency adjustments, and occasional tube replacement, little should be required in the way of maintenance. If a malfunction should occur, the technician should make every effort to locate a specific defective tube or component before "twiddling" any adjustment.

FREQUENCY MEASUREMENT AND ADJUSTMENT

CAUTION

DO NOT ATTEMPT TO TRANSMIT FOR AT LEAST 10 MINUTES AFTER THE VOLUME CONTROL POWER SWITCH IS TURNED ON. This period is required for the crystal ovens to stabilize the operating frequency. During the first few minutes after power is applied, the frequency changes so much that in addition to your signals being unintelligible, the output frequency will be in violation of FCC Regulations.

NEVER attempt to adjust any oscillator frequency in this equipment without a good quality digital frequency counter of known accuracy.

Any quartz crystal will gradually change frequency with time. The rate of change depends upon many factors. The crystals supplied with this equipment have been specially selected and aged at the factory but they will require periodic adjustment to frequency.

The IF oscillator, TEL receiver oscillator, and all transmitter output frequencies should be periodically measured and the results logged. The aging rate as revealed by this log should be used as a guide for scheduling regular measurement and adjustment intervals which will assure that the operating frequencies will remain within the specified limits at all times.

For shore stations, the total permissible deviation from assigned is ±20 cycles per second. For shipboard installations, deviation of ±50 cycles per second is permitted.

The crystal ovens in this equipment are temperature controlled at 75° C. by means of precision, hermetically sealed snap-action switches. Some temperature (and frequency) cycling can be expected at a 1 to 5 minute rate, depending upon ambient temperature. The amount of this short term variation should be less than 6 or 7 cps on the 22-mc band and much less on the lower frequencies. When the frequencies are being measured, sufficient successive readings should be taken to identify these short term cycles so that the mean operating frequency can be established.

IF OSCILLATOR FREQUENCY

The IF Oscillator Frequency should be 10010.0 kc unless otherwise marked. A test jack labeled "IF OSC TEST" is provided on the chassis near V19. The counter should be connected through a high impedance probe to this jack. Connection to other points could affect the accuracy of this measurement.

TRANSMITTING FREQUENCIES

The output frequency can be measured by connecting the counter through a suitable attenuator to the antenna jack near the top of the chassis. A capacitive divider works well. The RF voltage at the antenna jack will be of the order of 100 volts but will depend upon the impedance of the load or antenna.

1. Set the IF Oscillator exactly at 10010.000 kc
2. MODE switch on SSB
3. TUNE-OPERATE switch to LO PWR TUNE
4. MEASURE the output frequency
5. If necessary, adjust the channel oscillator frequency.
6. Take several consecutive output frequency readings to be sure that the short-term cycling is about the desired mean frequency.
7. Enter the results in the log book.
8. TUNE-OPERATE switch to HI PWR OPERATE.

TEL RECEIVER OSCILLATOR FREQUENCIES

These oscillator frequencies may be measured at the white "phono" plug coming from the oscillator or at V2, pin 1. Use a coupling capacitor for d-c isolation if the latter test point is used.

The required frequency can be calculated from the following formulae:

For channel frequencies below 10 mc,
crystal frequency = IF frequency − channel frequency.

For channel frequencies above 10 mc,
crystal frequency = channel frequency − IF frequency.

1. Measure the IF Oscillator frequency
2. MODE switch to SSB
3. Measure the Channel Oscillator Crystal Frequency.

VOLTAGE CHART

TUBE No.	TUBE Type	*	TUBE PIN NUMBER 1	2	3	4	5	6	7	8	9
V1	12BZ6	RS	0	0	0	12.6a	275	0	0		
		RT	0	2.6	0	"	140	160	0		
		T	0	0	0	"	275	0	0		
V2	12BE6	RS	0	0	0	"	215	0	0		
		RT	2.5	8.5	0	"	215	100	0		
		T	0	0	0	"	215	0	0		
V3	12BZ6	RS	0	0	0	"	275	0	0		
		RT	0	1.2	0	"	220	100	0		
		T	-70	0	0	"	275	0	0		
V4	12BZ6	R	0	1.6	0	"	100	130	0		
		T	0	1.6	0	"	100	130	0		
V5	12BE6	R	-130	0	0	"	275	215	-120		
		T	-10	0	0	"	260	105	0		
V6	12BE6	RS	-8	0	0	"	215	105	0		
		RT	0	0	0	"	215	0	0		
		T	-10	0	0	"	215	0	-70		
V7	12BZ6	RS	0	1.2	0	"	220	105	0		
		RT	0	0	0	"	275	0	0		
		T	-70	0	0	"	275	0	0		
V8	6GK6	R	0	-130	0	6.3a	0	0	275	275	0
		T	7.5	0	0	"	0	0	275	275	0
V9, V10, V11	6883B	R	0	12.6a	0	0	-52	0	0	0	
		T	1	"	215	1	-52	1	0	0	
V12	12BZ6	R	0	1.2	0	12.6a	210	100	0		
		T	0	1.2	0	"	210	100	0		
V13	6BH6	R	-4.5	.5	6.3a	"	210	0	0		
		T	-2.0	1.3	6.3a	"	210	85	0		
V14	12BA6	R	0	0	0	"	210	120	1.2		
		T	-70	0	0	"	215	0	0		
V15	12AX7	R	160	0	1.3	"	0	120	0	2.5	6.3a
		T	170	0	1.4	"	0	45	0	1.5	6.3a
V16	12AT7	R	215	85	90	"	0	0	0	0	6.3a
		T	215	90	95	"	0	0	0	0	6.3a
V17	6GK6	R	8.5	0	0	"	6.3a	0	260	275	0
		T	0	-70	0	"	6.3a	0	275	275	0
V18	7360	R	0	0	-130	"	6.3a	215	215	27	27
		T	4.5	150	0	"	6.3a	150	150	27	27
V19	6RA8	R	60	-3	60	0	6.3a	125	1	3.5	0
		T	60	-3	60	0	6.3a	125	1	3.5	0
V20	12AX7	R	150	0	1.2	0	12.6a	115	.5	0	6.3a
		T	150	0	1.2	0	12.6a	70	.5	0	6.3a
V21	12AT7	R	270	-7	0	12.6a	0	115	0	2.4	6.3a
		T	140	0	0	12.6a	0	125	0	2.5	6.3a
V22	OA2	R	150	0	0	0	150	0	0		
		T	150	0	0	0	150	0	0		

* Control Positions for the above indications

R (RECEIVE)

SPEAKER	ON
VOLUME	ON
SENSITIVITY	MAXIMUM CLOCKWISE
TRANSMITTER	NORMAL
MODE	SSB
BAND	4MC
STATION	ANY
TUNE-OPERATE	HI-PWR OPERATE

RS (RECEIVE SHIPS)

SAME AS FOR RECEIVE EXCEPT:
STATION SHIP A OR SHIP B

RT (RECEIVE TEL)
SAME AS FOR RECEIVE EXCEPT:
STATION TEL A OR TEL B

T (TEL TRANSMIT)
SAME AS FOR RECEIVE EXCEPT:
STATION TEL A OR TEL B
TUNE-OPERATE TX LOCK

Note: All voltages measured to ground with a Hewlett-Packard Model 410C VTVM.

The designation "a" following the voltage indicates an a-c voltage.

4. If necessary, adjust the channel oscillator to frequency.
5. Enter the results in the log book.

REPLACEMENT PARTS

When ordering replacement parts for this equipment, specify the following:

Equipment Model Number
Equipment Serial Number
The Circuit Symbol of the desired part.

See the Warranty Statement in this manual for instructions on how to obtain replacement of parts under the terms of the warranty. All of the information requested above must be provided.

TROUBLESHOOTING

In a system as complex as this transceiver, it is not practical to list all possible troubles and all possible cures for each. The technician must rely on past training and experience, as well as thorough familiarity with the circuits involved.

The following table is included mainly to assist shipboard personnel in effecting emergency repairs and tube replacement. See Section II, Specifications, for replacement tubes.

TROUBLESHOOTING CHART

Defect	Possible Cause
SHIP receiver sensitivity low TEL receiver sensitivity normal	1. K3 relay contacts dirty 2. K2 relay contacts dirty 3. V6 or V7 defective
TEL receiver sensitivity low SHIP receiver sensitivity normal	1. Antenna relay contacts dirty 2. V1, V2, or V3 defective 3. V105 or V106 defective
Receiver Sensitivity low Transmitter current low	1. Antenna lead open 2. Antenna lead shorted 3. Defective antenna relay 4. V4, V12, V18 or V19 defective
Receiver sensitivity low Transmitter normal	1. V14, V15, V16 or V17 defective
No transmitter modulation Transmitter idling current normal Receiver sensitivity normal	1. SPEAKER switch not ON 2. Handset or cord defective 3. MIC gain too low 4. V20 defective
No transmitter current Receiver normal TRANS switch on NORMAL MODE switch NOT on REC SHIPS	1. Defective fuse in power supply 2. V21 defective 3. K1 defective
Transmitter does not function on VOX	1. VOX gain too low 2. V21 defective
Transmitter current low on TEL channels without modulation. SHIP channels normal	1. V13 defective
Transmitter idling current normal on SHIP channels. Transmitter current low on TEL channels. No modulation	1. V5, V8, V18 or V20 defective
Receiver normal Insufficient transmitter current	1. V9, V10, or V11 defective. (Unless a tube tester is available all 3 of these PA tubes should be replaced as a group.) CAUTION: HIGH VOLTAGE

SECTION VIII

ALIGNMENT

GENERAL

This equipment should not require alignment except over very long periods of time. Alignment should never be attempted as a substitute for, nor as an aid to troubleshooting. Alignment should never be attempted by an unskilled technician or by anyone without adequate test equipment. All procedures should be read and thoroughly understood before any portion of the alignment is attempted. Before deciding to perform partial alignment, determine that all functions, transmit and receive, affected by that alignment can subsequently be checked with the test equipment on hand. The procedures should always be made in the order given.

Equipment Required:

1. Audio frequency generator.
2. 250-watt, 50 ohm dummy load.
3. VTVM: Hewlett-Packard 410C or equivalent.
4. Frequency counter: Hewlett-Packard 5245L or equivalent with Hewlett-Packard 5261 Video Amplifier or equivalent.
5. RF Signal Generator: Hewlett-Packard 606A or equivalent.
6. Coil adjustment tool: Walsco 2543 or equivalent.

Preliminary Adjustments

1. Remove front panel
2. TRANSMITTER switch OFF
3. SPEAKER to ON
4. VOLUME-POWER to OFF
5. MODE to SSB
6. BAND to 4 mc
7. STATION to SHIP A or B
8. Jumper antenna jacks (J4-J5) together. Connect the 50 ohm dummy load.
9. TUNE-OPERATE switch to HI PWR OPERATE
10. POWER ON. Wait 20 minutes.

IF Oscillator Frequency Adjustment

1. Measure the IF OSC frequency at the IF OSC TEST jack J-3 with a high-impedance probe. It must be 10010.000 kc ±2 cps.
2. If necessary, adjust frequency with IF OSC FREQ capacitor C1903.

Transmit Oscillator Amplifier Plate Coils Adjustment

1. With the -15vdc VTVM probe on V6, pin 1, (Common to chassis) measure oscillator injection voltage on each band. It must be -4.5 to -10 volts.
2. If the above limits are not met, adjust L401 through L405.

Receive Oscillator Amplifier Plate Coils Adjustment

1. STATION TO TEL A or TEL B
2. With the -15vdc VTVM probe on V2, pin 1 (Common to V2, pin 2) measure voltage on each band. It must be between 4.5 and -10 volts.
3. If the above limits are not met, adjust L101 through L105.

Balanced Modulator and 1st IF Amplifier

1. Connect 5vac VTVM probe to the junction of C1205 and C1206.
2. Connect a two tone audio signal of .05 VRMS amplitude to the microphone input terminals.
3. MIC GAIN to maximum.
4. TUNE-OPERATE switch to TX LOCK.
5. Adjust T1801 top and bottom cores and the core in T1201 for maximum VTVM reading. Reduce MIC GAIN as necessary to keep VTVM reading below 5 volts.
6. TUNE-OPERATE switch to HI PWR OPERATE.

Second IF Amplifier

1. Connect a CW signal generator to V12. pin 1 and adjust its frequency for an audible beat note in the speaker.

2. Adjust T1202 and T1402 for maximum S-Meter reading.

DRIVER GRID and PA GRID bandpass circuits.

1. TRANSMITTER switch ON. Wait 1 minute.
2. Tune and load the P.A. for each band. (See Section V).
3. BAND switch on 4 mc
4. STATION switch on SHIP A or B, whichever has crystals installed. If no SHIP crystals are installed, transfer a set of the TEL Transmit crystals and ovens to the SHIP oven sockets.
5. Connect a frequency meter or counter through an attenuator to the dummy load.
6. Connect the VTVM RF probe to the dummy load.
7. Connect a cable terminated in 50 ohms between the signal generator and a .001 to .01 capacitor to the junction of C1205 and C1206.
8. Connect a .001 capacitor in series with a 1000 ohm 1/2 watt resistor between V6, pin 7 and ground.
9. Connect a .001 capacitor in series with a 1000 ohm 1/2 watt resistor between V8, pin 7 and ground.
10. Adjust the signal generator to approximately 1 volt output at 10.01 mc.
11. TUNE-OPERATE Switch to TX LOCK.
12. Adjust the signal generator for an output frequency of exactly 4100 kc at the dummy load. The amount of voltage as measured on the VTVM will be small due to the heavy loading of the Driver Grid and PA Grid tank.
13. Carefully adjust the BOTTOM cores (those nearest the terminals of the cans) in T501 (4mc DRIVER GRID), and T801 (4mc PA GRID) for maximum VTVM reading.
14. Note: Before turning the BAND switch, always return the TUNE-OPERATE switch to HI PWR OPERATE, so that the transmitter is not keyed.
15. Repeat Steps 11 through 14 for each band, adjusting the coils for the band in use. The band-center frequencies are as follows.

BAND	CENTER FREQUENCY
4 mc	4100 kc
6 mc	6300 kc
8 mc	8230 kc
12 mc	12375 kc
16 mc	16512 kc
22 mc	22050 kc

16. Remove the 1000 ohm loading network from V6, pin 7 and connect it to V7, pin 5.
17. Remove the 1000 ohm loading network from V8, pin 7 and connect it to V9, pin 5.
18. Repeat Steps 12 through 15 except adjust the TOP cores in each of the bandpass transformers.
19. Remove the 1000 ohm loading networks.
20. Return the crystals if any were moved in Step 4.

Carrier Level Adjustment

1. Adjust the -40, -16, and -6db carrier levels according to the VTVM or OSCILLOSCOPE procedures in Section V.

TEL Receive Antenna and TEL Receive Mixer Grid Tanks.

1. These tanks may be peaked in the conventional manner on the TEL RECEIVE channel in use nearest the center of each band. The center frequencies are given below:

BAND	CENTER FREQUENCY
4mc	4400kc
6mc	6300kc
8mc	8775kc
12mc	13170kc
16mc	17325kc
22mc	22690kc

PA NEUTRALIZATION

1. Tune and load the transmitter on all bands to a PA cathode current of 150 ma.
2. On each band quickly detune the PA tune above and below resonance and note the off-resonant cathode current. If the PA is neutralized, this current will be equal on either side of resonance.
3. If the above step indicates that neutralization is necessary:
   a. Turn off all power.
   b. Wait 2 minutes
   c. Short the plus 800 volt line to chassis.

d. Rotate C907 about 5°.
e. Remove the short from the +800 volt line.
f. Apply power and repeat Step 2.

4. Repeat Steps 2 and 3 until neutralization is obtained on all bands.

HARMONIC TRAPS

Note: The Harmonic Traps are factory-aligned and should not be disturbed unless tests indicate that they are in need of adjustment. The need for such adjustment should occur only if the settings have been disturbed or the components have been physically damaged.

1. Perform the complete TUNE-UP procedure with a 50 ohm dummy load connected to the antenna jacks.

2. Connect a well shielded receiver through a coax cable to a high impedance attenuator to the transmitter dummy load.

3. On each band obtain a convenient reference level on the receiver level indicator while transmitting on the AM mode.

4. Substitute a signal generator for the transmitter and adjust its frequency for maximum receiver level indication. Duplicate the receiver input level obtained in Step 3 for each frequency. Record the receiver input level.

5. Reconnect the transmitter and operate exactly as before but tune the receiver to the harmonic of the transmitter frequency.

6. Again substitute the signal generator for the transmitter and adjust it for maximum receive level at the harmonic frequency. Determine the receiver input level necessary to duplicate the indications in Step 5.

7. The second harmonic level in Step 6 should be at least 66 db below that in Step 4 on each band. If it is not, adjust the trap capacitor for minimum harmonic output.

8. Retune the transmitter and repeat the harmonic measurement.

OSCILLATOR FREQUENCY ADJUSTMENT

The transmitter output frequencies and receiver frequencies are the result of adding or subtracting the IF Oscillator frequency and the Channel Oscillator Crystal frequencies.

The IF Oscillator frequency is 10010.000kc.

The required crystal frequency for any channel frequency can be determined from the following formula:

For channel frequencies below 10mc:

Crystal Frequency= 10010.000kc minus channel frequency.

For channel frequencies above 10mc:

Crystal Frequency=Channel Frequency minus 10010.000kc.

The most common frequencies used in this country are shown on the chart in on page 2.

All crystals and ovens for use in this equipment should be obtained from this manufacturer. The crystals must be equivalent to MIL-CR27A/U but in addition they and the associated ovens are specially tested, processed and aged prior to shipment to assure that they will meet the specifications required by this application.

No attempt should be made to set the IF Oscillator or any Channel Oscillator frequency unless a good quality digital frequency counter of known accuracy is available. The stability of the oscillators in this equipment is superior to most test equipments available. The crystal frequencies must be within 20 cps of the specified channel frequencies for shore stations and must be within 50 cps for ship stations.

Each of the individual crystal frequencies can be properly adjusted and measured without placing the transmitter on the air. Because of the amount of time required to set each frequency, it is recommended that the frequencies be adjusted according to the following procedure. As a final check, the transmitter output frequencies can be quickly determined later. Note that the setting of the IF Oscillator frequency is extremely important as this oscillator is used on all transmit and receive frequencies.

All of the crystals for frequency control in this equipment are mounted in precision ovens that maintain their temperature at plus 75° C. The temperature of the ovens is regulated by snap-action thermostats so that the temperature actually cycles at a rate of approximately once per minute slightly above and slightly below the nominal temperature. As a result of this small temperature variation (approximately ± 0.1° C.) the crystal frequency will also vary slightly above and below a mean at the same rate. The normal amount of frequency change will vary from less than 1 cps to as much as 3 cps, depending on crystal frequency.

Each time the crystal frequency is measured, it should be maintained over a period of time sufficient to determine the amount of cycling and the mean frequency. The counter gate should be set to 1 second.

A slight transient is encountered each time a thermostat operates. While this is seldom heard in the receiver, it will affect the counter when it is connected to the specified test point. The effect will be to cause an erroneous count if it occurs while the counter gate is open. This will be apparent as a reading of many cycles different from the normal frequency reading. It should not be confused with the slight variation as a result of temperature cycling.

All crystal oven power is applied at the time the power switch is turned on. The oven temperatures will stabilize within 10 minutes as noted earlier, sufficiently to permit operation of the equipment but it is recommended that the ovens be allowed to operate at least 30 minutes before attempting to set the crystal frequency. This will insure that final stabilization is complete.

Do not overlook the fact that most counters require a longer period of time to stabilize than the ovens in this equipment. The frequency stabilizing circuits in most counters remain on anytime the unit is connected to a 117-volt source. If this is the case with your equipment, you may be accustomed to use immediately after turning it on at the shop. If you remove the counter from the maintenance shop and take it to a vessel or other location to measure frequency, be sure to allow sufficient time for it to stabilize.

CONSULT YOUR FREQUENCY COUNTER MANUAL OR FACTORY REPRESENTATIVE TO DETERMINE THE TIME REQUIRED FOR STABILIZATION OF COUNTER TIME BASE. ALLOW SUFFICIENT TIME FOR COUNTER STABILIZATION BEFORE MAKING FREQUENCY MEASUREMENTS.

The oscillator voltage at the test points may drop to less than .1 volt when a low impedance cable is connected. If the Hewlett-Packard 5245L Counter is used it will be necessary to use a Hewlett-Packard 5261A Video Amplifier or equivalent.

IF Oscillator Frequency

1. Measure the frequency at the IF OSC TEST jack J-3.
2. Adjust to 10010.000kc ±2 cps with IF OSC FREQ capacitor C1903.

TEL Transmit Crystal Frequencies.

1. Place the STATION switch on the desired TEL channel.
2. Place the MODE switch on RECEIVE SHIPS. This will activate the TEL TX oscillator with the radiotelephone in receive condition.
3. Connect the counter to the TX OSC jack J-2 or disconnect the black phono plug from this jack and connect the plug to the counter video amplifier.
4. Locate the proper frequency adjusting capacitor on the Channel Oscillator Assembly. The adjusting capacitors are miniature air variables which go from maximum to minimum capacity in 180 degrees of rotation. They are set at the factory so that clockwise rotation from the present position will increase oscillator frequency.
5. Make the necessary frequency adjustments as determined from the crystal tables.
6. Remove the adjustment screwdriver and monitor the frequency for at least one minute to determine that the cycling is above and below the desired mean frequency.
7. Note: This adjustment is very critical on the higher frequencies but it should be possible to set the frequency to within 2 cps of the desired frequency.

SHIP Crystal Frequencies

1. Place the STATION switch in the desired SHIP position and proceed exactly as above. The MODE switch may be in any position for SHIP stations.

TEL Receive Crystal Frequencies

1. Place the STATION switch in the desired TEL position.
2. Place the MODE switch on SSB.
3. Connect the counter to the RX OSC Jack J-1 or disconnect the white-banded phono plug from this jack and connect it to the counter video amplifier.
4. Proceed as above.
5. Replace both plugs into the correct jacks.

TRANSMITTER OUTPUT FREQUENCY

After the adjustment of IF and Channel Oscillator frequencies as outlined above, the actual transmitter output frequency should be measured on each channel.

1. Loosely couple the counter to the antenna jacks, either with an insulated pickup probe or through a suitable attenuator network.
2. Select the Band and Station desired.
3. Place the MODE switch on SSB.
4. Place the TUNE-OPERATE switch in LO PWR TUNE
5. Measure and record the transmitter frequency.

RECEIVER FREQUENCY

The most practical method of adjusting the receivers to frequency is by setting the individual channel oscillators and the IF Oscillator as outlined above.

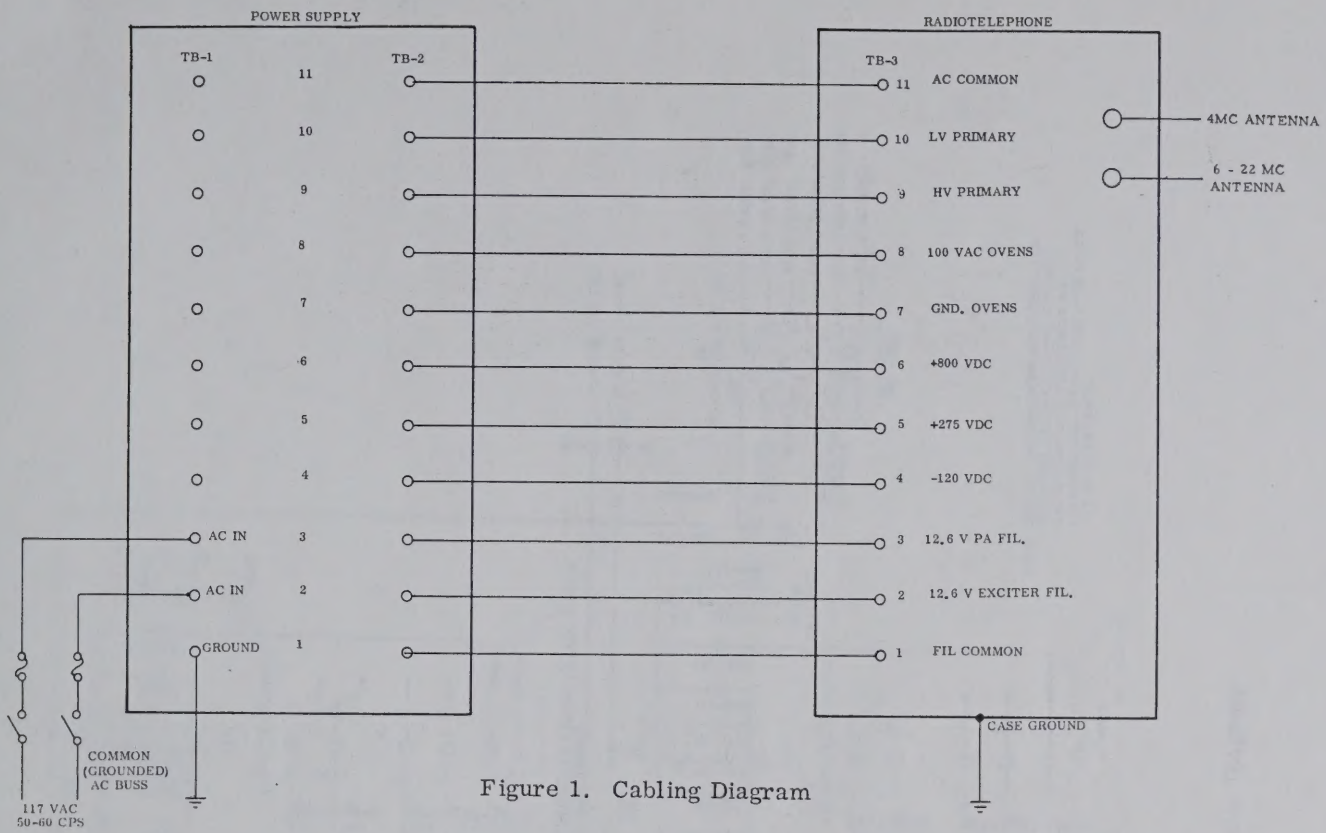


Figure 1. Cabling Diagram

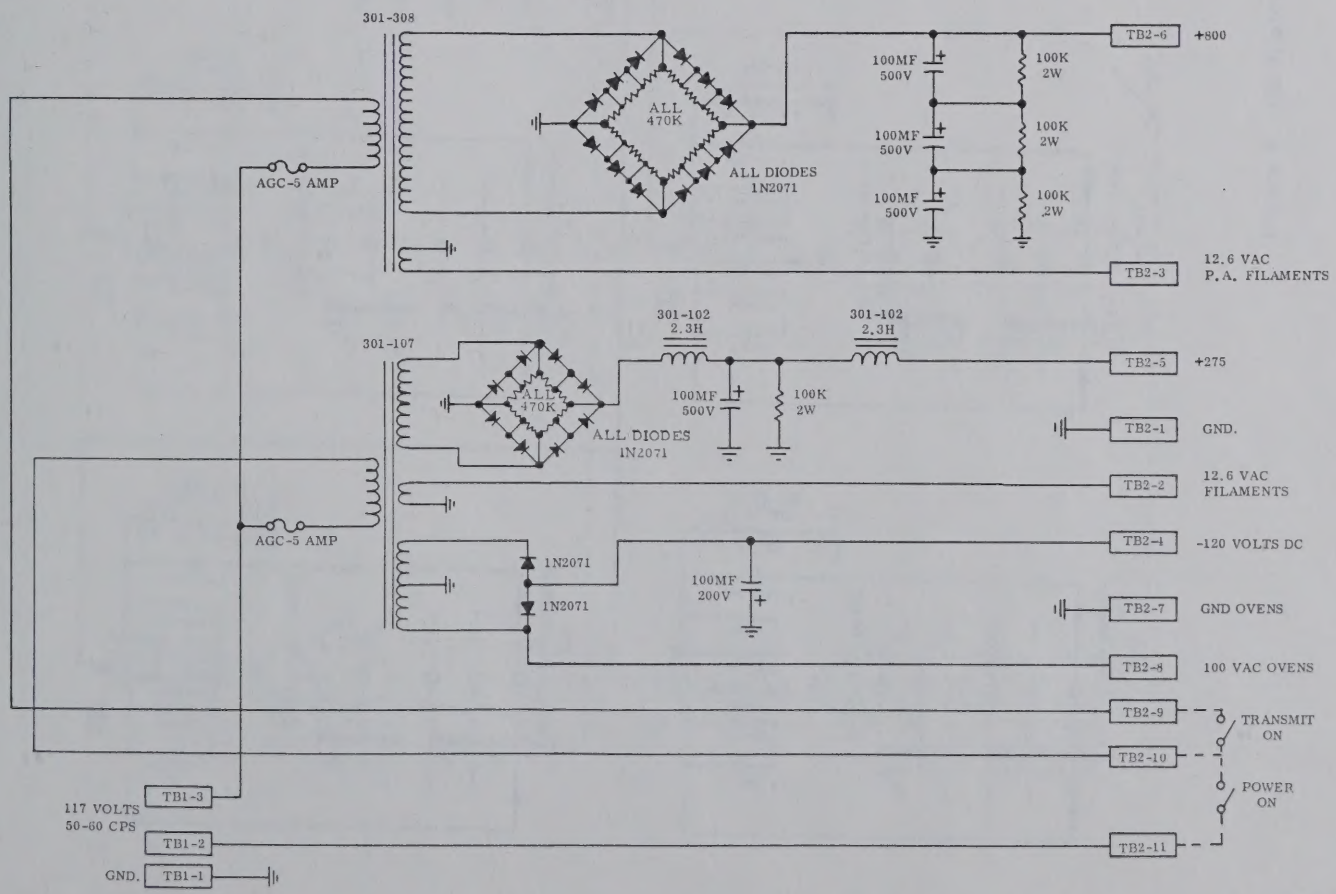
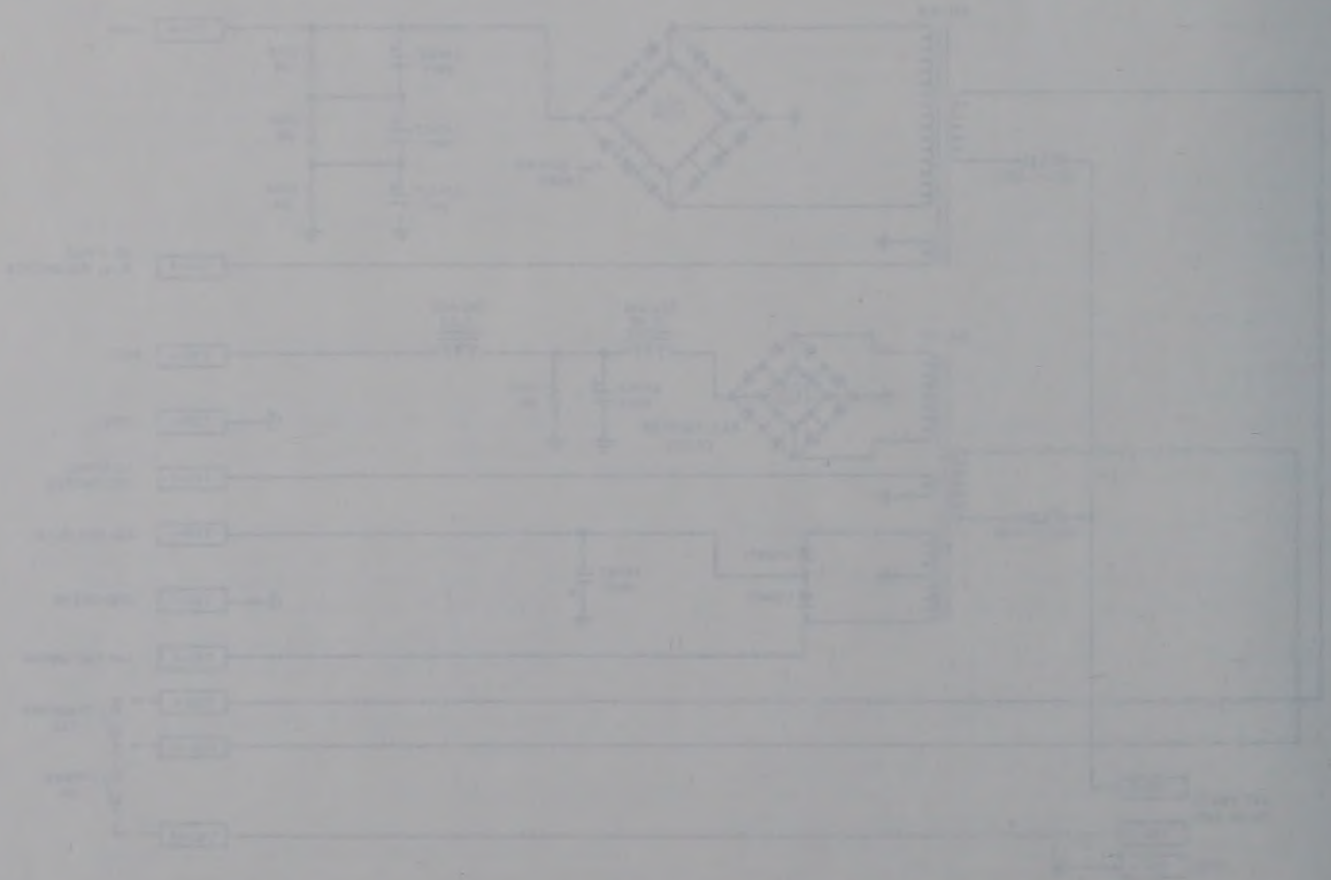
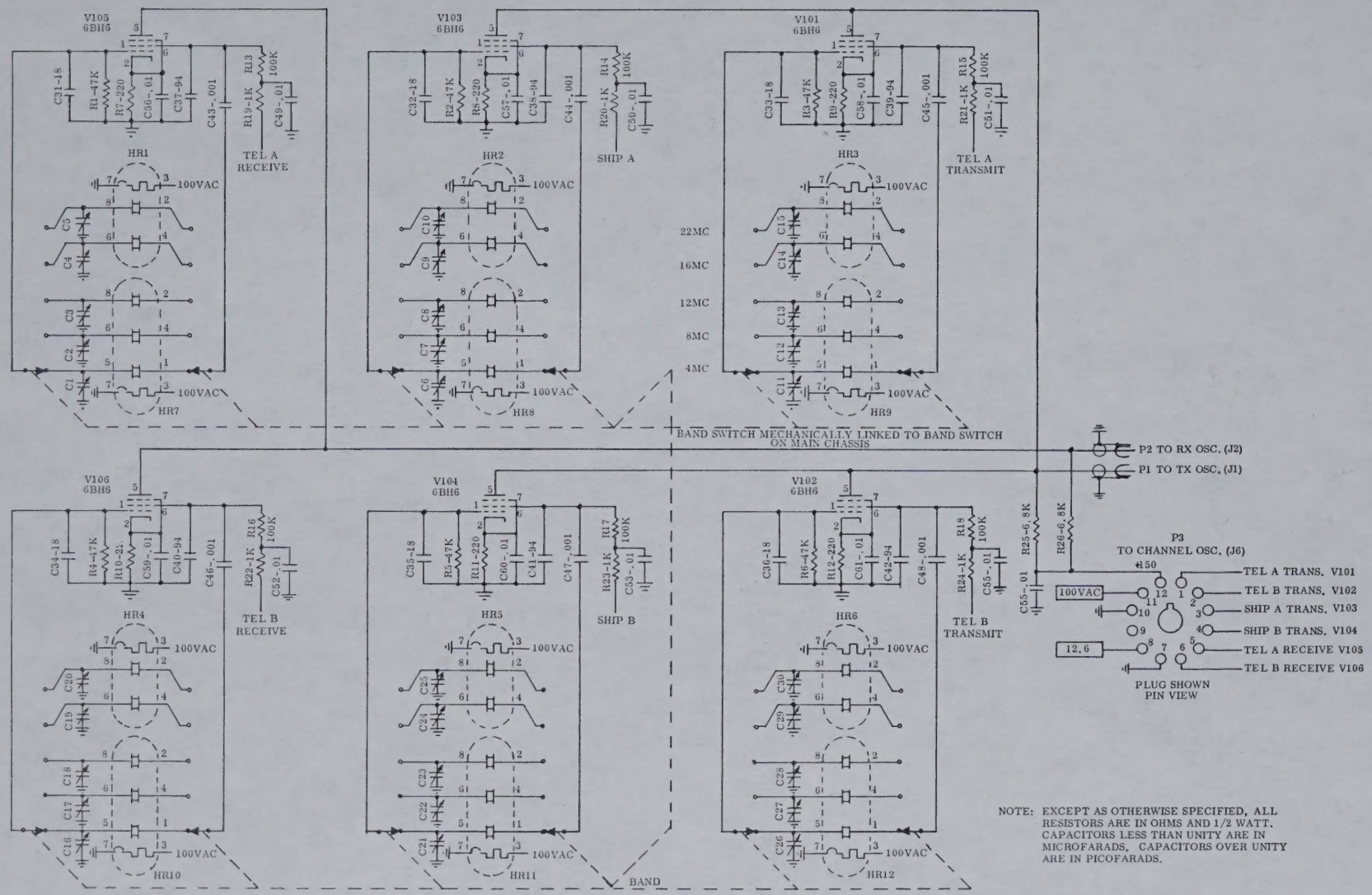


Figure 2. Power Supply Schematic Diagram





NOTE: EXCEPT AS OTHERWISE SPECIFIED, ALL RESISTORS ARE IN OHMS AND 1/2 WATT. CAPACITORS LESS THAN UNITY ARE IN MICROFARADS, CAPACITORS OVER UNITY ARE IN PICOFARADS.

Figure 4. Oscillator Schematic Diagram